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8 September 1955

CMCC Doc. No. 151.691
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Dear Dick:

We are forwarding herewith five copies of Informal Monthly Progress Report No. 2 covering the work performed on System No. 2 during the period extending from 11 July 1955 to 14 August 1955. It is probable that you are already in possession, as a result of our recent discussions, of all of the basic information contained in this report.

Sincerely,

Burt

Burt

Enclosures:
CMCC Doc. No. 163.2010
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Informal Monthly Progress Report No. 2

for the period

11 July 1955 to 14 August 1955

System No. 2

Contract No. A-101

CMCC Document No. 163.2010

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CONTENTS

1-0. GENERAL.

1-1. Informal Monthly Progress Report No. 1 described the results of an experiment intended to determine the feasibility of a system which measured the phase difference of signals generated on separate antennas by the same transmitted signal. The results of these experiments indicated the system as then implemented was not a sufficiently precise means of solving the navigational problem.

1-2. During the interval covered by this report, alternate methods of determining the position of aircraft were considered and the most promising of these methods was selected for experimental investigation. This method will measure the integrated doppler frequency due to the motion of the aircraft toward or away from existing low-frequency transmitters. The method selected is discussed and described in the following paragraphs. Instrumentation necessary for experimental investigation of its practicability is presently being designed.

2-0. AN ALTERNATE SYSTEM.

2-1. Navigation systems operating in the low-frequency band offer attractive possibilities, particularly if the radiation of existing friendly or unfriendly low-frequency broadcast transmitters are used. With respect to signal-to-noise performance, a narrow-band system which makes use of carrier-frequency power only should be capable of reliable operation at long range from a low-frequency transmitter.

2-2. The feasibility of systems using conventional direction-finding techniques was investigated. The chief obstacle to the use of conventional loop structures is due to the fact that horizontally polarized down-coming components of the received skywave cause erroneous bearing indications. It was found, however, that this error could be avoided by designing an Adcock-type aircraft antenna system using four annular slot antennas in the aircraft skin. The principal objection to such a direction-finding antenna configuration is the necessity for structural changes in the aircraft.

2-3. A navigation system was devised which would operate on the carrier frequency radiation of low-frequency broadcast transmitters and which would not require a special aircraft antenna structure. The most promising configuration of this system is one which measures the integrated doppler frequency due to the motion of the aircraft toward or away from the transmitter. Basically, this system would establish a ground station at which each cycle of the carrier frequency of two, separated low-frequency transmitters would be counted continuously. At the same time, the aircraft would be suitably equipped to count continuously each cycle of the carriers transmitted by the same two transmitters. As the aircraft moves toward, or away from these transmitters, the number of cycles counted will change correspondingly due to doppler effect. In addition to these counting devices, the base station and the aircraft would be equipped so that the ground station could be informed of the frequency count at the aircraft at any specified time. If a periodic comparison of the counts at the aircraft and the counts at the ground station are made, the integrated doppler frequency is represented by changes in the difference between these counts. Changes in the value of the integrated doppler frequency between comparisons is a measure of the aircraft movement toward or away from the transmitters. Synchronization of the time of comparison of aircraft and ground counts and transmission of the aircraft count to the base station would be accomplished by a high-frequency communication system.

2-4. See figure 1. As presently conceived, both the aircraft and the ground equipment will include two or more narrow-band low-frequency receiver and counter circuits, only one of which is shown in the figure 1. Each cycle of the received carrier will be counted continuously and a periodic comparison of aircraft and base-station counts for each low-frequency transmitter will be made.

2-5. Comparison of aircraft equipment and base-station counts is accomplished by the high-frequency link. When an interrogation pulse is sent from the base station to the aircraft by means of the high-frequency link, the base-station count at that instant is stored without stopping the main counter, and a secondary synchronization counter is started. When the interrogation pulse is received by the aircraft, the aircraft count is stored and a pulse is immediately returned to the base station. When the returned pulse is received at the base station, the synchronization counter is stopped and its count is preserved. The stored value of the aircraft count is then transmitted to the base station where it is recorded.

2-6. After the delays inherent in the electronic portion of the equipment are subtracted, the count in the synchronization counter represents the round-trip travel time of the interrogation pulse. One-half of this round trip value represents the travel time of the interrogation pulse from base station to aircraft, and this value is subtracted from the recorded aircraft count to correct for the time lag in reading the aircraft counter due to the travel time of the interrogation pulse.

2-7. When the aircraft is stationary, the difference will remain constant from interrogation to interrogation. If, however, the aircraft moves toward or away from the low-frequency transmitter, the difference between aircraft and base station counts will change proportionately to the number of wave lengths in a direction toward or away from the transmitter that the aircraft has moved between interrogations. If the initial count difference is determined at a time when the position of the aircraft is known, such as before take-off, subsequent periodic determinations of the integrated doppler with respect to two transmitters will determine the motion and position of the aircraft with respect to the original position.

2-8. Since it is necessary to continue integration without interruption after the aircraft has left its original position, system reliability will be increased by using four low-frequency receivers and counters operating on four low-frequency stations instead of the minimum two.

2-9. It is apparent that only a few significant digits must be retained in the counters since it is only possible for the aircraft to move within a limited region between interrogations, and this limits the maximum possible change in count difference.

2-10. Means of obtaining additional navigational information to give at least approximate position in case of interruption of the counting operation at aircraft or base station are being studied. If the ionospheric height of reflection is known or can be estimated, one such means is the high-frequency link itself, since the round-trip travel time is a measure of range from the base station.

2-11. Present development effort is directed toward design of those system components necessary for experimental evaluation of the integrated doppler navigation system described above. Equipment presently under development includes a miniaturized high-frequency transmitter, a low-frequency receiver, counter circuits, propagation mode discrimination circuits, a delay-line pulse integrator, a coded pulse-train generator, and necessary timing and gating circuits.

3-0. CONCLUSIONS. Results of preliminary theoretical investigation and consideration of the integrated doppler system described in this report indicate that the system holds sufficient promise of success to warrant the design and construction of an experimental equipment suitable for investigating its practicability.

4-0. MAN-HOURS EXPENDED. During the period covered by this report [redacted] man-hours were expended in this effort.

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